# BIONOMICS AND BIOCONTROL EFFICIENCY OF *ANASTATUS* SP. (EUPELMIDAE: HYMENOPTERA), AN EGG PARASITE OF *CHORISONEURA BILIGATA* (SERVILLE) (BLATTELLIDAE: DICTYOPTERA)[1]

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*(With nine text-figures)*

**Key words**: Egg parasites, cockroach, bionomics, biocontrol, *Chorisoneura biligata, Anastatus* sp.

In the course of this study, it was found that the ootheca of the cockroach *Chorisoneura biligata* (Serville) was parasitized by an eupelmid species, *Anastatus* sp. which shows morphological resemblance to *Anastatus tenuipes* in many respects, but differs in the general coloration, size and in the tips of male antennae. The duration of its life cycle was between 26 and 35 days. Although absolute host specificity was not found, a single female by ovipositing in 3 oothecae contributes to the control of 36 - 54 host eggs.

## INTRODUCTION

Insect parasites of cockroaches have attracted the attention of many investigators. Roth and Willis (1954a, 1954b) have given details of distribution, development, behaviour and sex ratios of several entomophagous parasitoids belonging to orders Hymenoptera, Diptera, and Coleoptera which infest cockroaches. The biology of the encyrtid parasite, *Camperia merceti,* developing in the eggs of *Blattella germanica* and *Supella longipalpa* had been thoroughly investigated by Lawson (1954) and Zimmerman (1944). The genus *Anastatus,* family Eupelmidae, is known to parasitize the eggs of several species of cockroaches. *Anastatus floridanus* has been recorded from the oothecae of *Blatta orientalis, Periplaneta americana* and *Eurycotis floridanus,* the last named species being the natural host for that eupelmid parasite (Roth and Willis 1954a). Flock (1941) studied the development, rate of parasitization and sex ratio of *Anastatus tenuipes.* The biology of *Anastatus* sp. parasitic on the eggs of *S. longipalpa* was studied by Ananthasubramanian and Ananthakrishnan (1961). Uma *et al.* (1982 a,b) studied the biology of *Anastatus umae* parasitic on the eggs of *Neostylopyga rhombifolia.* In the family Eulophidae *Tetrastichus hangenowii* was found to parasitize the eggs of several species of cockroaches such as *Periplaneta americana, Blattella germanica* and *Blatta orientalis* (Takahashi 1924, Sonan 1924, Bodenheimer 1930, Rau 1940, Usman 1949, Roth and Willis 1954a). Schal *et al.* (1984) studied the interspecific associations of cockroaches. Bhoopathy (1995) studied the bionomics of the evaniid parasite *Brachygaster minutus* (Oliver), parasitic on the eggs of the cockroach *Blattella humbertiana* Saussure. The parasites such as nematodes and protozoans were also found in the intestines of cockroaches (Bhoopathy 1996). A number of parasites and predators were listed by Bhoopathy (1986) in some cockroach species.

Bionomics and life history of hymenopteran parasitoids were studied by Nikam *et al* (1987). Baktharatchagan (1993) and Panicker and Srinivasan (1992) worked out the biology of *Anastatus tenuipes* parasitic on the brown banded cockroach *Supella longipalpa.* Uma (1992) did comparative biological studies on the two oothecal parasitoids *Comperia merceti* and

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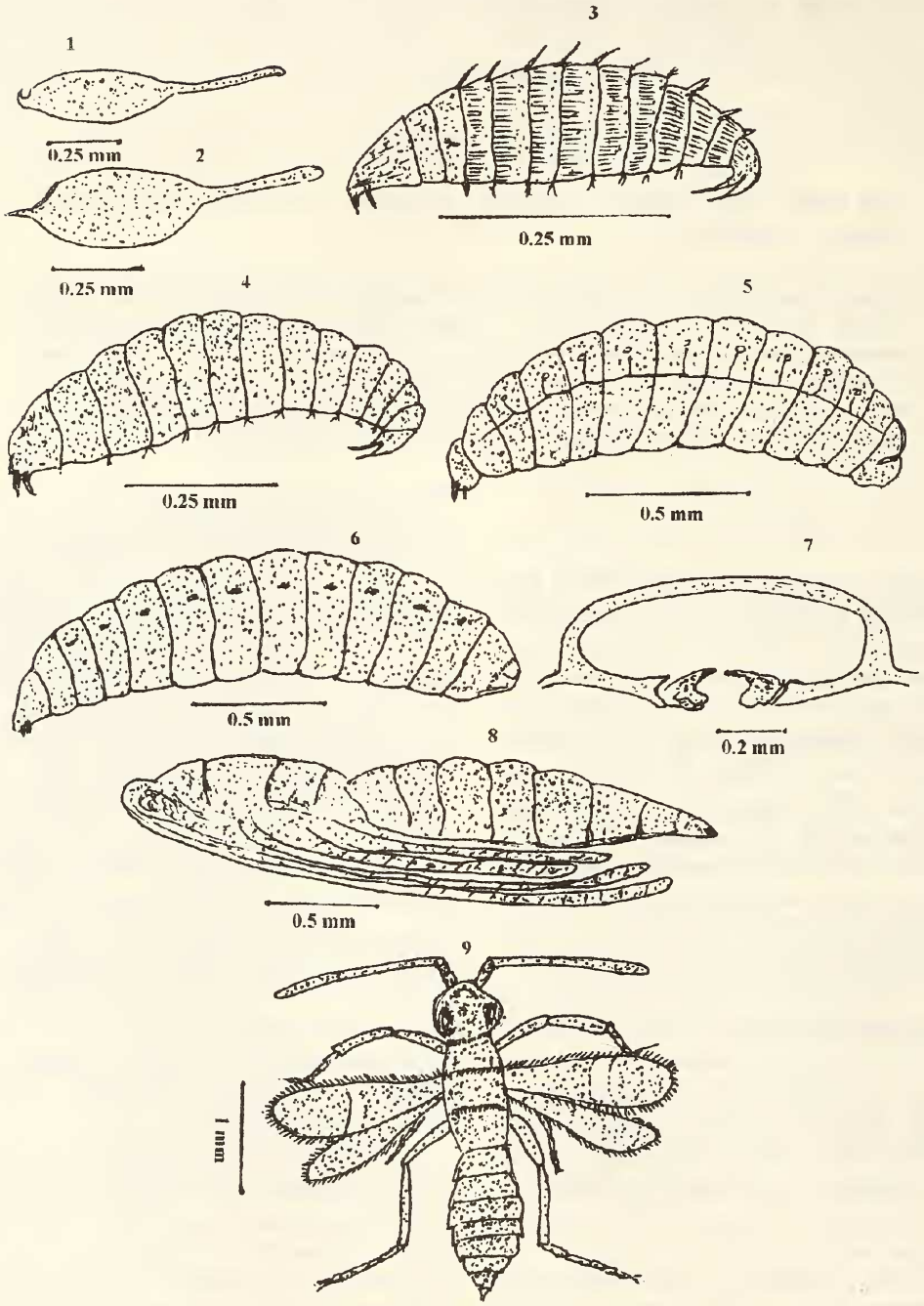


Figs. 1-9: 1. Freshly laid egg; 2. Egg enlarged during incubation; 3. First instar larva; 4. Second instar larva; 5. Third instar larva; 6. Mature larva; 7. Mandibles of mature larva; 8. Pupa; 9. Adult female.

*Anastatus tenuipes*. The reproductive strategies of the egg parasitoid *Trissolcus* sp. was studied by Senrayan *et al.* (1988). The efficiency of parasites and their development in relation to the age of the host was studied by Kumarasingha and Jayanthi (1987), on oothecal parasites of *Periplaneta americana*.

However, no information was available on *Anastatus* sp. except for the two references mentioned above. In the present study, the bionomics of *Anastatus* sp. parasitic on *Chorisoneura biligata* and its biological control efficiency were investigated.

## Material and Methods

Oothecae of *C. biligata* glued on the host plants were collected and reared individually in test tubes measuring 10 x 1.5 cm, plugged with cotton wool. The parasites could be seen when the oothecae were held against light, especially in the later stages of parasite development. When the adult parasites emerged from the oothecae, they were fed on droplets of honey and kept alive. Freshly deposited oothecae of *C. biligata* were exposed to *Anastatus* sp. for parasitization, to study the host hunting and ovipositing behaviour of the parasite. Parasitized oothecae were reared in test tubes, and a few of them were dissected in normal saline at intervals of 24 hours to study the parasitoid eggs, larval and pupal stages. The eggs and immature stages of the parasite were mounted in glycerine to study their structure.

To determine the efficiency of biological control by the egg parasite, enough oothecae were offered for oviposition and the number of adults finally emerging from them were counted. Unmated females of *Anastatus* sp. were offered host eggs, to find out whether parthenogenesis occurred and the fate of offspring resulting from that phenomenon. Adult parasites were reared by feeding them honey solution, prepared by dissolving one part of honey in 5 parts of water, in order to observe the behaviour of the adults, longevity, fecundity and mating behaviour.

## Results

Bionomics of *Anastatus* sp., parasitic on the egg of *Chorisoneura biligata*.

### Immature stages

**Egg**: Nearly cylindrical, oblong, stalked, stalk nearly as long as egg and club-shaped; a short, slender, recurved flagellum at the opposite end of egg; the flagellum straightens when the egg swells up after it is inserted into the ootheca. Ovarian egg black, the hue fading to translucent after being deposited into ootheca. Length of egg 0.65 mm, including stalk; stalk 0.3 mm long; flagellum 0.4 mm; egg swelling up about 3.5 times its size within an hour after deposition.

Dissections on ootheca of *C. biligata* egg-capsules soon after parasitization by *Anastatus* sp., revealed 25-45 eggs of the parasite per ootheca. The duration of egg stage was found to be 2-3 days. Five to nine eggs of the parasite out of 25-45 did not hatch, accounting for nearly 20% egg-mortality.

### First instar larva

Agriotypiform, body elongate, distinctly 13-segmented and characterised by a pair of caudal processes, usually bent at right angles to the long axis of the body, their length equalling the combined length of the first two segments. Head conical, equipped with a pair of short, conical, recurved, highly chitinised mandibles; general coloration of larva pale white, head and first two segments maroon with black; each segment except the 1st and 2nd with a row of backwardly directed spines, more conspicious ventrally and laterally; spines in the anterior segments longer. The larva is 0.5-0.6 mm long and 0.2 - 0.22 mm wide; caudal processes about one tenth as long as body (0.040-0.05 mm).

The number of first instar larvae per ootheca was found to be 20-36. The larvae move actively, churning the contents of the host eggs. The mortality rate of the parasite at this stage appears to be as high as 50%. Oothecae cut open

about a week after parasitization revealed only 10-18 second instar larvae; this number was found to coincide with the number of dead specimens of the 1st instar, the duration of which was found to 3-5 days. The moulted skins of the first instar larvae appear to be consumed by the later larval stages.

**Second instar larva**

Hymenopteriform, lacking the conspicuous spines of the preceding stage; body about one and a half times as long as the first instar larva; cylindrical, with short, sparse spinules; caudal processes much reduced, 0.02 mm long, being about one-sixth of the body length, mandibles dark brown; length of larva about 0.75 mm. Colour milky white. Duration 3-4 days.

**Third instar larva**

Robust, about twice as long as the second instar larva; body smooth, devoid of spines; caudal processes disappearing, caudal segment bilobed; tracheal tubes opening to the exterior by spiracles; spiracles 10 pairs located in the first ten segments. Length 1.5-1.8 mm. Duration 3-4 days.

**Fourth instar larva**

Similar to the preceding stage, except for its larger size; body distinctly segmented, 2-2.1 mm long; mandibles much reduced; spiracles distinct; coloration light yellow; full grown larva fits snugly into the ootheca, prior to pupation. Duration 3-4 days.

**Pupa**

As in other species of the family; larval skin of last larval stage forming the cocoon; coloration at first yellowish, gradually turning to light brown, deep brown and black in regular sequence; duration 12-15 days.

**Emergence of the adult**

The adults were seen moving about within the ootheca for 6-12 hours before one of them cut a circular exit hole of about 0.2 mm diameter. Often, the adults remain within the oothecae for 2 to 3 days or more; in such oothecae for some unknown reason no exit hole is made; if such oothecae are carefully split open, the insects emerge out one by one. Rarely, two exit holes are found on the ootheca located just below the keel at one end of the ootheca. Most of the adults cast off their meconia before emerging from the ootheca, while it is not uncommon to note some adults emerging with the meconia hanging from their abdomen, and they are discarded soon. In some cases, the adults emerge in batches.

A total of 10-18 adults have been noticed to emerge from each ootheca (Table 1).

TABLE 1
DURATION OF EGG AND LARVAL STAGES AND SEX RATIO IN *ANASTATUS* SP.

| S. No. Parasitized Ootheca | Duration of egg and larval stages in days | No. of adults emerged | No. of females | No. of males | Sex ratio |
|---|---|---|---|---|---|
| 1. | 32 | 14 | 10 | 04 | |
| 2. | 30 | 16 | 15 | 01 | |
| 3. | 28 | 10 | 09 | 01 | |
| 4. | 28 | 14 | 10 | 04 | |
| 5. | 26 | 10 | 08 | 02 | |
| 6. | 26 | 12 | 10 | 02 | |
| 7. | 35 | 14 | 04 | 10 | |
| 8. | 30 | 14 | 11 | 03 | |
| 9. | 25 | 18 | 18 | — | |
| 10. | 27 | 14 | 13 | 01 | |
| 11. | 27 | 13 | 03 | 10 | |
| 12. | 35 | 14 | 12 | 02 | 2:1 |
| 13. | 30 | 14 | 13 | 01 | |
| 14. | 32 | 10 | 09 | 01 | |
| 15. | 32 | 12 | — | 12 | |
| 16. | 35 | 16 | 09 | 07 | |
| 17. | 30 | 14 | 10 | 04 | |
| 18. | 26 | 14 | 10 | 04 | |
| 19. | 9 | 14 | 08 | 06 | |
| 20. | 26 | 16 | — | 16 | |
| Total | | 271 | 180 | 91 | |

**Duration of life-cycle and number of generations per year**

The duration from oviposition to the emergence in *Anastatus* sp. was found to be 26 -

35 days at a temperature of 28-31°C and relative humidity of 65-90%. Nearly half of this period is spent on the pupal stage, and as many as 11-12 generations are completed per year if host eggs are accessible.

**Adults and their behaviour**

The adult female of *Anastatus* sp. measures 2.0 - 3.1 mm long. General coloration black; head jet black, eyes dark metallic black; thorax dark brown; antennae yellowish brown, pedicel pale white; forewings with a transverse fascia at about half the distance from the bases, fringed with fine bristles; hindwings much shorter and smaller than forewings; legs light brown except coxae and trochanters which were black; abdomen black dorsally and light brown ventrally, except the anterior one-third which is pale white. Males much shorter than females, measuring 1.25-1.85 mm long. Abdomen black; forewings extending beyond abdomen.

Like other eupelmids, *Anastatus* sp. is ant-like in its general appearance. Both sexes were quite active, preferring walking as the normal mode of movement, but at the least disturbance they jump vertically. Only under repeated stimulation did they take wing, flying short distances. The jumping habit is perhaps the chief mode of locomotion (Clausen 1940).

**Food and Feeding habits**

In the present study, adult females of *Anastatus* sp., were observed to puncture the host eggs for oviposition but not for feeding. However, in a few instances, the females were found to feed on the fluid that oozed out of the oviposition puncture. The adults did not appear to feed at all and lived for 2 or 3 days only. Under laboratory conditions it was, however, possible to keep the adults alive for 7-10 days on a diet of dilute honey.

Copulation occurred immediately after emerging from the host ootheca. A single male was found to mate with 1 - 10 females. Females also copulate 1 - 3 times. Copulation lasted 3-16 seconds.

**Host selection and oviposition**

*Anastatus* sp. did not demonstrate host specificity, in the laboratory the female oviposited successfully into the oothecae of domiciliary species such as *Supella longipalpa, Blatta orientalis* and *Periplaneta americana.* Its life history in these atypical hosts was not followed up in the present study. After copulation, the female *Anastatus* sp. hunted for the ootheca of the host cockroach; on encountering an ootheca, it tapped the ootheca with the antennae, presumably to test the suitability of the ootheca for oviposition. Oothecae containing eggs that were already parasitized, were decidedly avoided, as was experimentally confirmed in the present study. Antennal sensory cells serve to select the specific site of oviposition in the oothecae. The ovipositor also appeared to have a sensory function — the tip of the ovipositor was gently struck at various points on the ootheca before piercing a specific region. After selecting the oviposition site and sitting on the ootheca with the long axis of its own body at right angles to that of the ootheca, the female inserted the ovipositor and moved it back and forth several times, presumably to anchor the eggs into the host eggs. Oviposition was completed in 35 - 50 minutes, and in one instance it was found to extend over a period of 90 minutes. A single female was found to attack upto three oothecae in quick succession and oviposited in all three. Further, it was observed that a single female oviposited into the same ootheca five times in the course of two hours. Parthenogenesis occurred commonly in *Anastatus* sp. and all the resulting offspring were found to be males.

**Sex-ratio**

Normally females predominated; often only one male emerged along with 9 - 17 females. However, the mean value of sex-ratio determined from 20 samples clearly showed the predomination of females as 2:1. In some instances, all the individuals emerging from fertilized eggs were male.

**Efficiency of biological control**

To find out the maximum number of host eggs that could be parasitized, five mated females kept alive in separate test tubes were offered 2, 3, 4, 5 and 6 oothecae. Observations were made from oviposition through development, until the adult parasite emerged. The results (Table 2) revealed that a single female was capable of ovipositing into as many as 3 oothecae, contributing to the control of 36-54 host eggs. It was noteworthy that a maximum of 18 adults of *Anastatus* sp. emerged in certain instances, where the female parasite had access to only one ootheca, while a maximum of 16 adults was found to have emerged when a single female was offered 3 oothecae. However, in many such cases; only 6-12 adults were found to have emerged.

TABLE 2
REALISED REPRODUCTIVE CAPACITY OF *ANASTATUS* SP.

| S. No. Female | No. of Oothecae offered | No. of Oothecae parasitized | No. of adult parasites emerged |
|---|---|---|---|
| 1. | 2 | 2 | 11 + 11 = 22 |
| 2. | 3 | 3 | 10 + 09 + 13 = 32 |
| 3. | 4 | 2 | 12 + 14 = 26 |
| 4. | 5 | 3 | 10 + 06 + 12 = 28 |
| 5. | 6 | 3 | 10 + 10 + 16 = 36 |

## DISCUSSION

In the course of this study, it was found that the ootheca of the cockroach *Chorisoneura biligata* was parasitized by the eupelmid species *Anastatus* sp., which showed morphological resemblance to *A. tenuipes* in many respects, but differed in general coloration, size and in the tips of male antennae.

The degree of host specificity of the hymenopterous egg parasites of cockroaches varied. Some parasites were absolutely specific, e.g., the encyrtid parasite, *Comperia merceti* attacked only the ootheca of *Blattella germanica* and would not parasitize the oothecae of *Periplaneta americana* or *B. orientalis* (Lawson 1954). Roth and Willis (1954b) could not induce the eupelmid parasite *Tetrastichus hangenowii* to attack the eggs of *B. germanica* and *Parcoblatta virginica*, its specific host being *Blatta orientalis*. Further, when that eupelmid species oviposited accidentally in the ootheca of *S. longipalpa*, the parasite's eggs either failed to hatch, or if hatched, the larvae died soon. Edmunds (1953) could not induce *Prosevania punctata* to parasitize the eggs of *B.germanica*. Cros (1942) induced this evaniid parasite to oviposit into a mantid ootheca, but neither the mantid eggs nor the parasite developed. In the present study, *Anastatus* sp. which parasitizes the eggs of *C. biligata*, could also oviposit into the oothecae of *P. americana* and *Blatta orientalis* but the eggs deposited into such host eggs failed to develop. All these instances lead to the conclusion that the host specificity of the egg parasites of cockroaches appeared to be rather absolute, and any atypical or abnormal behaviour in this respect interferes with egg viability or results in arrested development of the parasite and the host.

## ACKNOWLEDGEMENTS

I thank Dr. Louis M. Roth, U.S. Army Research and Development Command, Natick, Massachusetts, U.S.A., for determining the taxonomic status of the blattid. I am indebted to Prof. Dr. K.S. Ananthasubramanian, Department of Zoology, Loyola College, Chennai for help and guidance. I also thank Dr. Z. Bôucek, Commonwealth Institute of Entomology, London for identifying the parasitoid.

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